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Editorial: Novel Materials for Green Soldering and Brazing

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Editorial on the Research Topic

Novel Materials for Green Soldering and Brazing

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In the field of electronics and packaging, Pb based solder (e.g., Sn-Pb) and Cd based filler (e.g., Ag-Cu-Cd) alloys were popularly used as the most reliable interconnection materials. Traditionally, these alloys were widely used materials for soldering and brazing in the industries of electronic devices and products. However, the RoHS (Restriction of Hazardous Substances) banned both Pb and Cd as hazardous to human health due to their toxic behaviors. Banning of such toxic materials has propelled the entire electronic industries for searching alternative and sustainable replacements. At the time of proposing this Research Topic on June 16, 2020, the electronic industries were experiencing a steady increase in the demand for finding viable Pb-free solders and Cd-free filler metals. It is evident that the scientific community must come together to explore sustainable alternatives. In this case, focus must be given on several critical issues including wettability, melting point, cost, availability, strength, corrosion resistance, thermal fatigue, etc. for finding the alternatives to Pb and Cd based alloys. In response to this challenge, Frontiers in Materials joined the global scientific community by proposing this Research Topic–"Novel Materials for Green Soldering and Brazing". The present Research Topic thus aimed to highlight a few examples of significant contributions that materials scientists can bring to the global platform. We particularly welcomed contributions that include, but were not limited to, the following topics and their applicants for addressing the problems identified in electronic industries:

- The alloying system of Pb-free solders and Cd-free filler metals and their related processing.
- Fabrication of Pb-free solders and Cd-free filler metals for green soldering and brazing.
- Properties, modeling and applications of Pb-free solders and Cd-free filler metals
- Reliability of Pb-free solder and Cd-free filler materials.

Accordingly, this brief themed article collection features four key contributions, as briefly summarized below, reporting precise respective abstracts. It is expected to give an expression and visibility to the interested stockholders with an overview of current research and developments in this sector.

Nur Amirah Mohd Zahri et al., focused on "Deformation and fracture behavior of sandwiched copper foam brazed joint using amorphous copper-tin-nickel-phosphorus filler". Utilization of open-cell metal foams in functional applications such as in energy absorption, noise absorber, heat insulator and lightweight panels become trending in many industrial application. The development of reliable joining technologies for sandwiched metal foams is crucial for heat e application and one of the technique used is brazing process. In current work, copper foam was sandwiched between copper plate using amorphous filler of Cu-9.7Sn-5.7Ni-7.0P (Cu-copper, Sn-tin, Ni-nickel, P-phosphorus) via brazing technique. The shear test was conducted on the brazed joint interface of copper/copper foam, while the compressive test was carried out on the brazed sample. Microstructures of the copper substrate surface obtained from the shear-fracture of brazed copper/copper foam show tear region and cleavage fractures. The stress-strain curve of shear and compressive explain the deformation behavior of the brazed sample.

Bang Jiang et al., focused on "Microstructure Evolution and Shear Property of Cu-In Transient Liquid Phase Sintering Joints". Transient liquid phase sintering (TLPS) is a promising joining technology that can achieve high-temperature resisted solder joints at low temperature, showing excellent potential in power electronics. In this work, Cu/Cu-In/Cu solder joints were successfully prepared by TLPS process. The effects of bonding pressure and holding time on the microstructure and shear strength of Cu-In TLPS joints at 260°C and 320°C were studied. The results showed that as bonding pressure increased from 0.1 to 0.6 MPa, the porosity decreased and shear strength increased significantly. No obvious change was found as bonding pressure continued to increase to 1 MPa. As holding time increased at 260°C, $Cu_{11}In_9$ was formed and gradually transformed to Cu_2In that can withstand elevated temperature. Meanwhile, the porosity decreased while shear strength increased. It was calculated that volume expansion (12.74%) occurred during the phase transition from $Cu_{11}In_9$ to Cu_2In. When bonding temperature increased to 320°C, only Cu_2In was detected and then gradually transformed to Cu_7In_3 with the growing holding time. As holding time reached 120 min, their porosity increased and lead to weak shear strength due to volume shrinkage (15.43%) during the phase transition from Cu_2In to Cu_7In_3.

Liang Zhang and Su-Juan Zhong focused on "Effect of Ni_3Sn_4 on the thermomechanical fatigue life of solder joints in 3D IC". In this paper, Ni/Sn/Ni joints simulated the 3D integration was carried out by TLP bonding (250°C, 0.2 N) with different bonding time. After TLP bonding, planner-type Ni3Sn4 IMC can be observed, when the bonding time is 180 min, complete Ni3Sn4 can be found. The diffusion coefficient D can be determined to be 32.4 μm^2/min. Based on finite element simulation, it is demonstrated that the shear stress and creep strain increases obviously with the increase of IMC thickness, the results calculated show that the IMC thickness can impact the fatigue life of solder joints significantly, with the increase the Ni_3Sn_4 thickness, the fatigue life of solder joints can be decreased obviously.

Deku Zhang et al., focused on "Effect of vacuum heat treatment on microstructures and mechanical properties of 7A52 aluminum alloy-Al_2O_3 ceramic brazed joints". This study investigated the interface morphology, microstructure composition and connection strength of 7A52 aluminum alloy-Al_2O_3 ceramic brazed joints under heat treatment conditions. Alumina ceramics were first treated with electroless nickel plating, followed by vacuum heat treatment at different temperatures. Then an Al-Si-Mg intermediate layer was placed between the treated alumina ceramic and 7A52 aluminum alloy for brazing under the conditions of welding temperature 590°C, holding time 1 h, pressure 2 MPa. Results showed that when heat treatment was performed at 350°C and below, the nickel-plated metal had an amorphous structure, and when performed at 400°C, the nickel-plated layer had a crystalline structure and the brittle phase Ni_3P was precipitated. When the heat treatment temperature was 350°C, the joint shear strength reached the maximum, which was 68.7 MPa.

AUTHOR CONTRIBUTIONS

MF wrote the first draft of the manuscript. All authors contributed to the manuscript revision, read and approved the submitted version.

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.